CHAPTER 4
REGIONAL MODELING AND EVALUATION

Chapter 4. Regional Modeling and Evaluation

4.1 Background

Regional air quality modeling is used to estimate community exposure to air toxics as a function of both time and geography due to known toxic emissions sources. The model-simulated concentrations of toxic compounds are translated into a spatial pattern of air toxics health risk based on the cancer potency and risk factors for each compound. The regional modeling method provides a mechanism to predict the transport of emissions from a variety of source categories as well as individual sources to estimate risk throughout the modeling domain. This analysis complements and is compared to the techniques used to assess concentrations and risks from the data acquired at the fixed monitoring sites.

For over the last 20 years the South Coast AQMD has used regional air quality models in air toxics risk analyses. In the MATES II analysis, the Urban Airshed Model with TOX (UAMTOX) chemistry was used to simulate the transport and accumulation of toxic compounds throughout the Basin. In this chapter, South Coast Air Basin is referred as SCAB or the Basin. UAMTOX was simulated for a protracted 2 km by 2 km grid domain that overlaid the Basin.

Subsequent to MATES II, the South Coast AQMD transitioned to more technologically advanced tools that use updated chemistry modules, improved dispersion algorithms, and mass consistent meteorological data. In the 2007 Air Quality Management Plan (AQMP) and the subsequent MATES III analysis, the dispersion platform moved from UAM to the Comprehensive Air Quality Model with Extensions (CAMx), enhanced with a reactive tracer modeling capability (RTRAC)[1] , and the diagnostic wind meteorological model was replaced by the Mesoscale Model version 5[2] prognostic model. CAMx, coupled with the MM5 input, using the "one atmosphere" gaseous and particulate chemistry, was used to simulate both episodic ozone and annual concentrations of $PM_{2.5}$ and air toxic pollutants. The modeling was performed based on the UTM coordinate systems.

In the 2012 AQMP, the South Coast AQMD transitioned from MM5 to a new mesoscale meteorological model, Weather Research Forecast[3] and adopted a statewide Lambert Conformal coordinate system. Both CAMx and Community Multiscale Air Quality (CMAQ) models were used for air quality simulations. Within the South Coast Air Basin (SCAB), both models performed similarly. For MATES IV, the CAMx RTRAC with WRF was used to model air toxic

[1] Ramboll Environment and Health, 2018. CAMx User's Guide Version 6.50. Novato, CA 94998

[2] Grell, G.A., Dudhia, J., Stauffer, D.R., 1994, A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5), NCAR/TN-398+STR, NCAR Technical Note

[3] Skamarock, WC, Klemp, JB, Duchia, J, Gill, D.O., Barker, D.M., Duda, M.G., Huang, X.-Y., Want, W, Powers, J.G., 2008, A Description of the Advanced Research WRF Version 3, NCAR/TN–475+STR http://www2.mmm.ucar.edu/wrf/users/docs/arw_v3.pdf

concentrations of both particulate matter and gaseous species. MATES V used the MATES IV modeling setup with the latest versions of CAMx and WRF.

The MATES V modeling was conducted over a domain that encompassed the Basin, portions of Coachella Valley (CV) and the coastal shipping lanes located off the shore of Los Angeles, Orange, and Ventura counties using a grid size of 2 km by 2 km. Figure 4-1 depicts the MATES V modeling domain. Compared to MATES IV, the MATES V modeling domain was extended further east by 40 km to include populated portions of the Coachella Valley. An emissions inventory for 2018 was developed based on the 2016 AQMP emissions inventory with updates using the 2018 reported point source emissions, the latest CARB on-road emission model (EMFAC2017)[4], and speciation profiles. Although the actual measurements and modeling for MATES V spanned the period from May 1, 2018 through April 30, 2019, for simplicity, the MATES V modeling used the 2018 emissions inventory, with day-of-week information reflected in the modeling emissions. Anthropogenic emissions change depending on the day-of-week, for example, heavy-duty truck traffic reduces significantly on weekends. Grid-based, hourly meteorological fields generated from WRF provided the wind, temperature, humidity patterns and other atmospheric parameters for the model simulations. Using the 2018 annual inventory to represent the MATES V period is not expected to significantly impact modeling results.

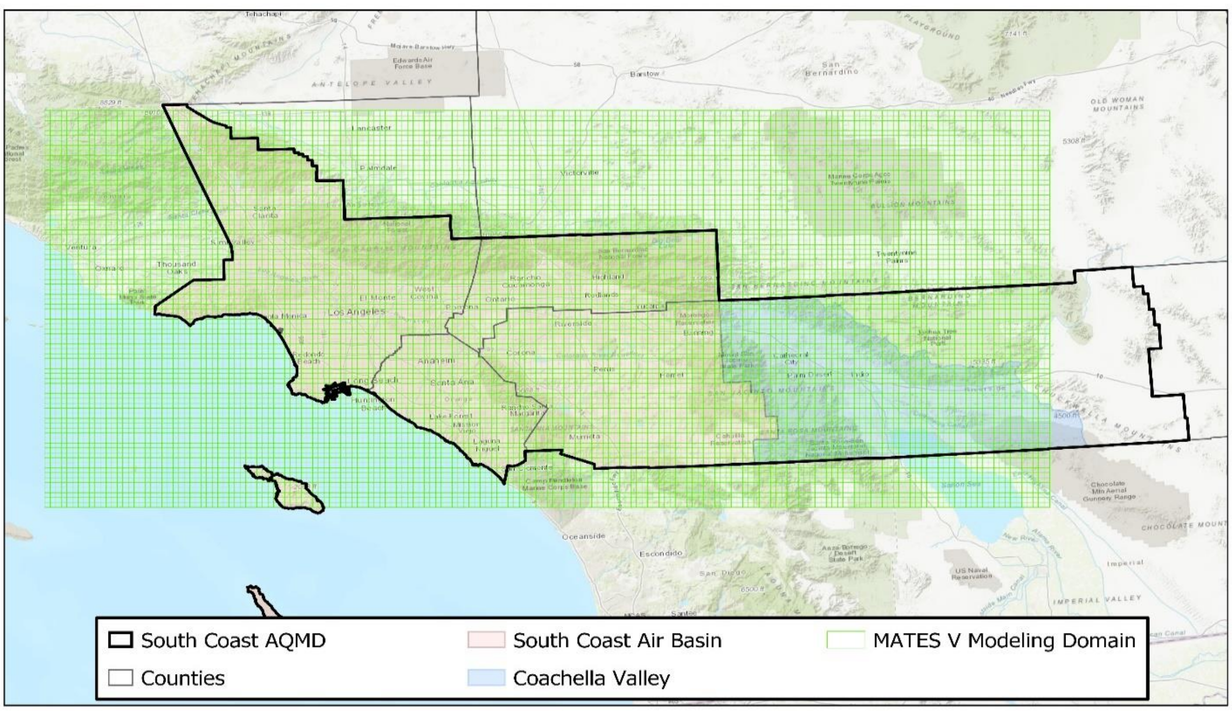

Figure 4-1.
MATES V Modeling Domain

[4] CARB, 2017, EMFAC2017 model and its documentation can be obtained at the following CARB link: http://www.arb.ca.gov/msei/modeling.htm

4.2 Modeling Setups

The MATES V regional modeling analyses relied on the CAMx RTRAC model to simulate annual impacts of both gaseous and aerosol toxic compounds. The accuracy of the modeling analyses depends on the accuracy of region-wide emissions of air toxic compounds, temporal and spatial resolutions of these emissions, accurate representation of meteorological conditions and quality of modeling tools used. The South Coast AQMD staff has been striving to use the best information and modeling tools available at the time for its MATES modeling analyses. The MATES V appendices provides the technical details about the emissions and modeling.

As in MATES IV, MATES V used the CAMx-WRF coupled system. WRF is a state-of-the-science meteorological modeling tool offering a variety of user options to cover atmospheric boundary layer parameterizations, turbulent diffusion, cumulus parameterizations, land surface-atmosphere interactions, which can be customized to model-specific geographical and climatological situations. The South Coast AQMD staff performed extensive sensitivity tests to improve WRF model performance for the South Coast Air Basin and surrounding areas, where the geographical and climatological characteristics impose great challenges in predicting the complex meteorological structures associated with air quality episodes. CAMx with RTRAC algorithms was employed as a chemical transport platform, given the importance of tracking chemically active toxic elements individually to assess the contribution of each source category. The RTRAC algorithm provides a flexible approach for tracking the emissions, dispersion, chemistry, and deposition of multiple gases and particles that are not otherwise included in the model's chemistry mechanisms. MATES V used the latest available version of models, compared model performances with Community Multiscale Air Quality (CMAQ) model, a model used in AQMP/State Implementation Plan modeling attainment demonstration, and available databases.

The MATES V modeling used the latest available emissions data. For major point sources, reported annual emissions were used. For area and off-road mobile sources, although annual emissions were based on projection in 2016 AQMP, the latest updated spatial surrogates were used to allocate county total emissions to a specific grid in the modeling domain. The EMFAC2017 emission factors along with SCAG's transportation modeling results for 2018, which provided a link-based midweek traffic volumes and speeds by vehicle types, CalTrans Performance Measurement System (PeMS) and Weigh-in-Motion (WIM) data, and ambient conditions from WRF modeling were used to generate spatially and temporally resolved on-road modeling emissions. The annual emissions from ocean-going vessels (OGV) from the CARB 2018 Updates to the California State Implementation Plan[5] were used. Emissions from OGV and commercial harbor craft (CHC) were spatially and temporally resolved using Automatic Identification System (AIS) data. All OGVs have emissions released through stacks, which result in the emissions penetrated to the computational layer 2 and higher, while CHC emissions were assumed to be released at the sea level due to the lower profile of a typical harbor craft. The latest biogenic emission model, Model of Emissions of Gases and Aerosols from Nature 3 (MEGAN3), together with WRF outputs were used to generate day-specific biogenic emissions.

[5] CARB, 2018, the 2018 Updates to the California State Implementation Plan, Available at https://ww3.arb.ca.gov/planning/sip/2018sipupdate/2018update.pdf

Table 4-1 summarizes the major components in the air toxics modeling and provides a comparison between the MATES V and MATES IV analyses.

Table 4-1
Summary and Comparison of Key Modeling Considerations Between MATES IV and MATES V

Parameter	MATES IV	MATES V
Meteorological Modeling Year	July 2012 - June 2013	May 2018 - April 2019
Model Platform / Chemistry	CAMx RTRAC (5.30)	CAMx RTRAC (6.50)
Meteorology Model /Vertical Layers	WRF with 30 layers/ CAMx: 16 layers	WRF with 30 layers/ CAMx: 16 layers
On-Road Mobile Emissions	EMFAC2011/2012 RTP SCAG Traffic Activity Fixed day of week and hourly distributions by Caltrans District	EMFAC2017/2016 RTP SCAG Traffic Activity Day-specific spatial and temporal distributions based on CalTrans PeMS/WIM data
OGV and CHC Emissions	2012 AQMP for 2012 OGV; Emissions spread through mostly layers 1 and 2; uniform spatial and temporal distributions	2018 SIP Update for OGV; Emissions spread through mostly layers 1 and 2; day-specific temporal and spatial distributions
Point Source Emissions	2012 Projection from 2008 (2012 AQMP)	2018 Annual Emissions Reports
Area Source Emissions	2012 Projection from 2008 (2012 AQMP)	2018 Projection from 2012 (2016 AQMP)
Off-Road Emissions other than OGV and CHC	2012 Projection from 2008 (2012 AQMP)	2018 Projection from 2012

4.3 Modeling Results

CAMx RTRAC regional modeling was conducted to estimate annual average concentrations of 19 key compounds measured as part of the MATES V monitoring program from May 1, 2018 to April 30, 2019. Simulated annual average concentration plots for the four toxic compounds that contributed most to the air toxics cancer risk throughout the domain (diesel particulate, benzene, 1,3-butadiene and formaldehyde) are depicted in Figures 4-2 through 4-5.

Figure 4-2 depicts the projected annual average concentration of diesel PM in the model domain. The highest concentration (1.13 μg/m^3) was simulated to occur around the Ports of Los Angeles and Long Beach. In general, the distribution of diesel particulates is aligned with the transportation corridors including freeways, major arterials and rail rights-of-way. The peak diesel concentration is much lower than the previous MATES studies, due in a large part to emission reductions from regulations and programs impacting in various categories of on-road and other mobile sources. Figures 4-3 and 4-4 provide the distributions of benzene and 1,3-butadiene respectively whereby the toxic compounds are almost uniformly distributed throughout the Basin, reflecting light-duty vehicle traffic pattern since benzene and 1,3-butadiene emissions are mostly from gasoline combustion. Benzene emissions are primarily from on- and off-road mobile sources, with portions emitted from refineries located near the coast. The modeled benzene concentrations mostly reflect patterns of the mobile sources with marginal enhancement near the coastal area. The 7 monitoring stations, Burbank, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach - showed the measured annual concentrations for benzene ranging from 0.22 ppb, the lowest at Burbank to 0.38 ppb, the highest at Compton with a 7-station average to be 0.29 ppb. Model prediction at those stations ranges from 0.21 to 0.28 ppb with a 7-station average to be 0.25 ppb, which are in reasonable agreement with the measurements.

The ambient concentrations of formaldehyde in the Basin are attributed to direct emissions, combustion sources, and secondary formation in the atmosphere. The formaldehyde concentrations shown in Figure 4-5 depict a spatial distribution indicative of its sources, with measurable concentrations in the heavily-traveled western and central Basin, with additional elevated levels in the downwind areas of the Basin that are impacted by higher levels of photochemistry and ozone formation. While the emissions from primary combustion sources decreased by approximately 8% since MATES IV, the MATES V measurements indicated the ambient formaldehyde concentrations increased compared to MATES IV. This increase means that the formaldehyde concentrations are being driven by secondary formation instead of direct emissions, indicating a complex chemistry involved in formaldehyde formation and depletion. The modeled concentrations from the 7 monitoring stations averaged at 1.61 ppb, lower than the measured values averaged at 2.95 ppb.

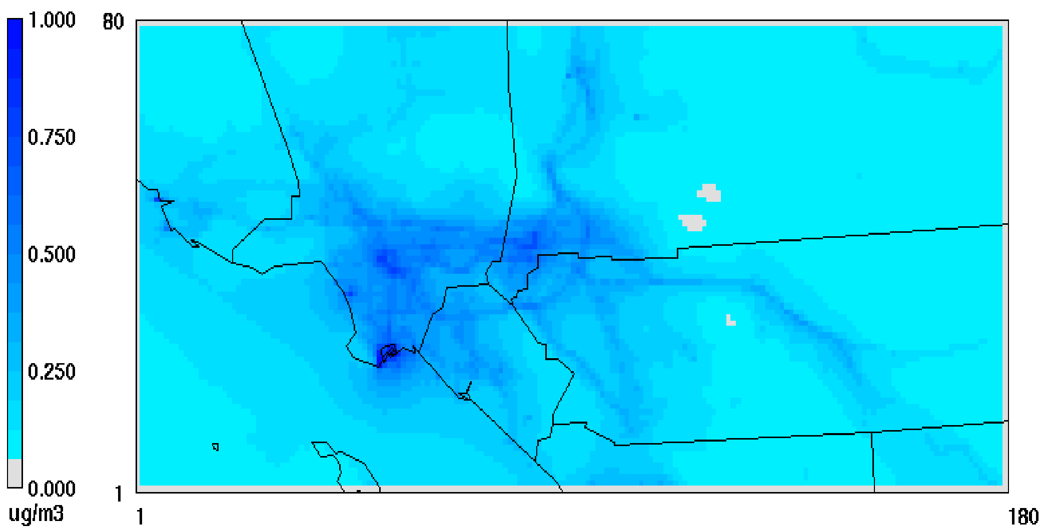

Figure 4-2
Annual Average Concentration Pattern for Diesel PM

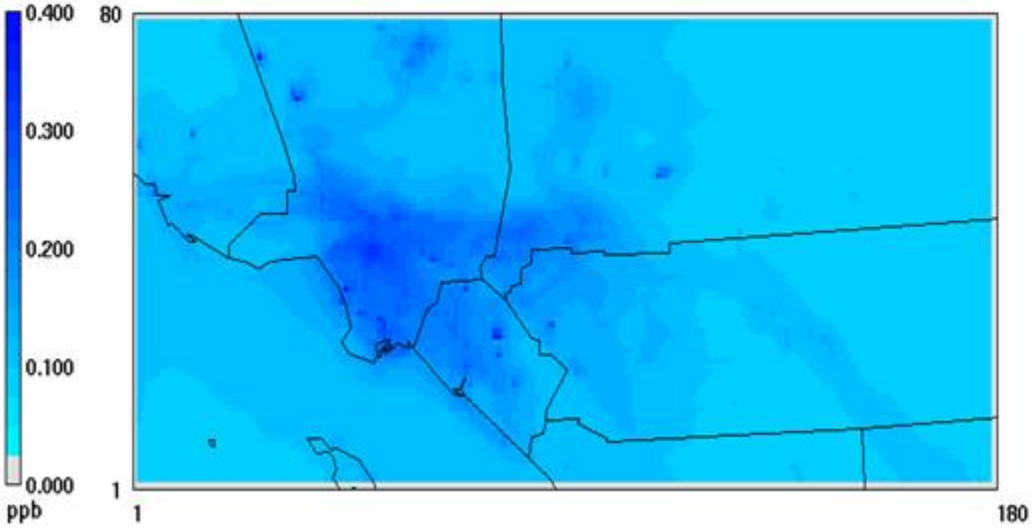

Figure 4-3
Annual Average Concentration Pattern for Benzene

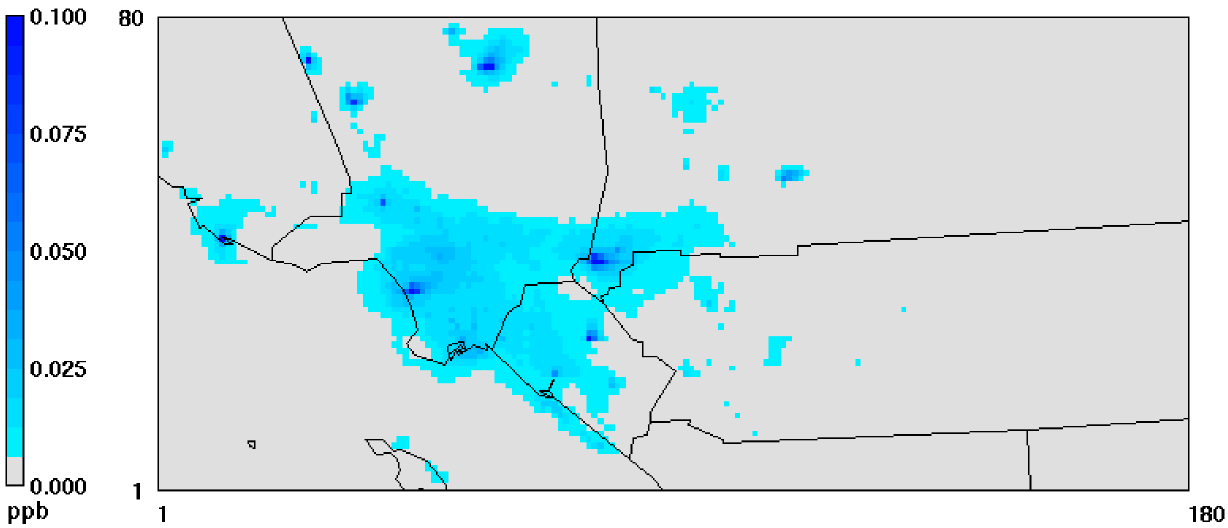

Figure 4-4
Annual Average Concentration Pattern for 1,3-Butadiene

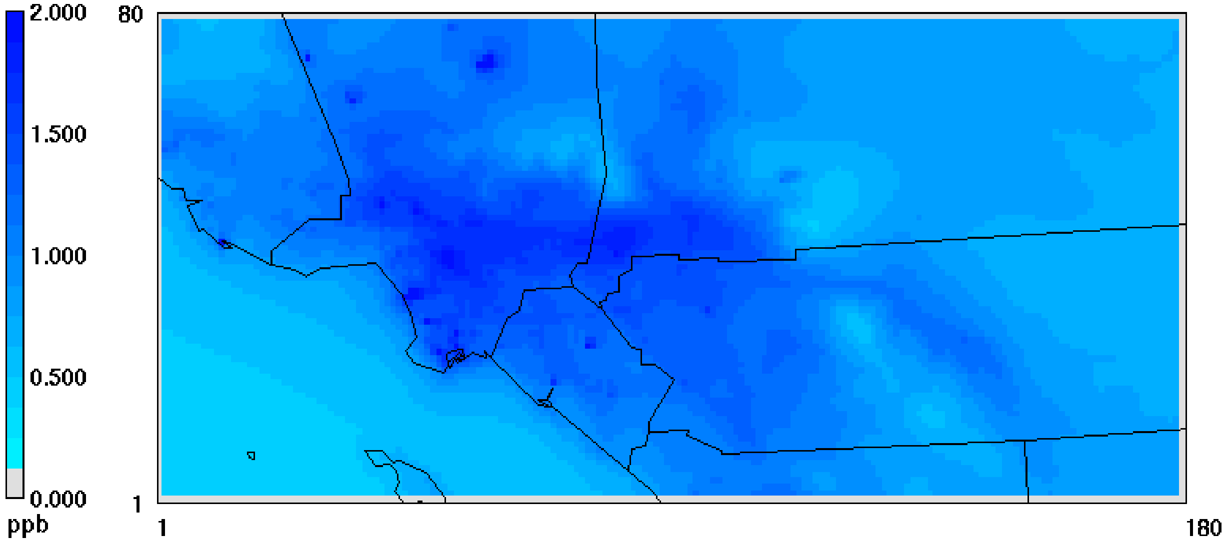

Figure 4-5
Annual Average Concentration Pattern for Total Formaldehyde

Table 4-2 provides a summary of the model performance relative to the actual measured annual average concentrations. For this comparison, the monitored data from seven stations (Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach) are combined to provide an estimate of average Basin-wide conditions for the MATES V sampling period for the gaseous species while 3 additional stations Anaheim, Los Angeles and Rubidoux are used as well for metals and EC. The CAMx RTRAC estimated concentrations at the monitoring sites were derived using the inverse distance-square weighted surrounding nine-cell average. Since direct measurements of diesel PM are not possible, no direct comparisons can be made with simulated annual average concentrations. However, using the methodology for converting measured EC into diesel PM as described in Chapter 2, the10-site average diesel PM concentration is estimated to be 0.48 $\mu g/m^3$.

The modeled average concentration corresponding to the average across the same 10 sites is 0.51 $\mu g/m^3$. Naphthalene was measured only at the Central Los Angeles and Rubidoux stations. For the rest of the species, each of the four counties within the South Coast AQMD jurisdiction is represented by at least one station.

Table 4-2
Measured and Modeled Annual Average Concentrations During MATES V

Compound	Units	2018-2019 MATES V	
		Measured Annual Average*	**Modeled Annual Average**
$EC_{2.5}$	$\mu g/m^3$	0.66	0.63
Cr 6 (TSP)	ng/m^3	0.040	0.032
As (TSP)	ng/m^3	0.52	0.51
Cd (TSP)	ng/m^3	0.32	0.65
Ni (TSP)	ng/m^3	3.14	4.21
Pb (TSP)	ng/m^3	4.80	3.61
Benzene	ppb	0.29	0.25
Perchloroethylene	ppb	0.03	0.02
p-Dichlorobenzene	ppb	0.03	0.03
Methylene Chloride	ppb	0.17	0.18
Trichloroethylene	ppb	0.02	0.01
1,3-Butadiene	ppb	0.06	0.02
Formaldehyde	ppb	2.95	1.61
Acetaldehyde	ppb	1.55	0.61
Naphthalene*	ng/m^3	62	26

* The table shows the average across all 10 stations for each of the particulate matter pollutants, the average across 7 stations for VOC pollutants except for naphthalene, which is the average across two stations.

The modeled concentrations of particulate matter species, such as $EC_{2.5}$ and TSP metals compared well with measured concentrations. The model performances for gaseous species are more mixed. Ambient concentrations of perchloroethylene, p-dichlorobenzene, and trichloroethylene have become so low such that the typical ambient concentrations are often below the measurement's method detection limits (MDLs). Thus, greater uncertainties exist in evaluating model performance against measurements for these species. However, the measured and modeled concentrations are in the same general ranges, as shown in Table 4-2. Given the low ambient concentrations of these three gaseous air toxics, their contribution to the overall air toxic cancer risk is less than one percent for each pollutant. For 1,3-butadiene, due to its highly reactive nature, large uncertainties exist in speciation profiles, and decay parameters used in the modeling as well as measurements. As a result good model performance for 1,3-butadiene is not typically expected. Accurate information on speciation profiles for naphthalene is limited. Naphthalene concentrations measured in MATES III, MATES IV and MATES V showed very low ambient concentrations and therefore very low air toxic cancer risk contributions. Benzene, which past MATES modeling showed remarkably good agreement between modeling and measurement results, was predicted reasonably well. Meanwhile, carbonyls, formaldehyde and acetaldehyde, were underpredicted. While carbonyl emissions continue to decrease, the measured carbonyl concentrations increased compared to MATES IV, which indicates potential uncertainties in multiple areas such as chemical mechanism, transport modeling, emissions inventory, and measurement. Further analysis and research are warranted to improve the understanding. Modeled and observed concentrations of methylene chloride compared well.

Modeled annual average concentrations of $EC_{2.5}$ were used to assess the overall model performance, especially diesel PM for the MATES V period. Tables 4-3 summarizes the MATES V $EC_{2.5}$ model performance.

The U.S. EPA's guidance[6] recommends evaluating particulate matter modeling performance using prediction bias and error. Prediction Accuracy (PA), calculated as the percentage difference between the mean annual observed and simulated $EC_{2.5}$ concentrations, is another tool used in the performance evaluation. PA goals of ±20% for ozone and ±30% for individual components of $PM_{2.5}$ or PM_{10} have been used to assess simulation performance in modeling attainment demonstrations in previous Air Quality Management Plans. PA indicated that $EC_{2.5}$ prediction meets the EPA performance criteria at eight out of 10 stations, with EC concentrations at Burbank overpredicted and Rubidoux underpredicted. A detailed discussion of the model performance is presented in Appendix IX.

[6] U.S. EPA, 2006," Guidance on Use of Modeled and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze NAAQS," U.S. EPA, Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division, Air Quality Modeling Group, Research Triangle Park, North Carolina.

Table 4-3
MATES V $EC_{2.5}$ Model Performance

Location	Observed ($\mu g/m^3$)	*Modeled ($\mu g/m^3$)	Prediction Accuracy	Mean Bias ($\mu g/m^3$)	Mean Error ($\mu g/m^3$)	Normalized Mean Bias	Normalized Mean Error
Anaheim	0.47	0.55	16	0.08	0.21	0.78	0.89
Burbank Area	0.50	0.67	33	0.17	0.33	1.06	1.22
Compton	0.80	0.66	-17	-0.14	0.42	0.59	0.86
Inland Valley San Bernardino	0.78	0.63	-20	-0.15	0.33	0.05	0.48
Huntington Park	0.68	0.66	-2	-0.02	0.32	0.74	0.97
Long Beach	0.52	0.62	19	0.10	0.28	1.53	1.67
Central L.A.	0.71	0.78	9	0.07	0.27	0.63	0.76
Pico Rivera	0.74	0.61	-17	-0.13	0.25	0.11	0.41
Rubidoux	0.69	0.42	-40	-0.27	0.35	0.06	0.60
West Long Beach	0.72	0.71	-2	-0.01	0.38	0.89	1.16
All Stations	0.66	0.63	-5	-0.03	0.31	0.64	0.90

* Included only the days that measurements are available. The sample frequency is one in every 6th day.

4.4 Inhalation-Only Cancer Risk

Previous MATES studies have focused on calculating air toxics cancer risk for the inhalation exposure pathway only. Since diesel PM was the dominant risk driver, and since this risk is driven by the inhalation exposure pathway, this approach accounted for the vast majority of the air toxics cancer risk in the region. Although diesel PM continues to be the major risk driver in the region, it is important to evaluate other air toxics that contribute to risk, which includes other exposure pathways such as oral or dermal exposures. First we describe the results from the evaluation of inhalation-only cancer risk, consistent with previous MATES studies. In Section 4.5 below, we describe the evaluation of multiple pathway risk, which includes inhalation as well as other exposure pathways.

Figure 4-6 depicts the MATES V distribution of inhalation cancer risk estimated from the predicted annual average concentrations of the key toxic compounds. Risk is calculated for each grid cell as follows:

$$\text{Risk}_{i,j} = \Sigma \ \text{Concentration}_{i,j,k} \text{ X Risk Factor}_k$$

Where i,j is the grid cell (easting, northing) and k is the toxic compound. The risk factor for a given compound is derived from its inhalation slope factor following OEHHA's 2015[7] risk assessment guidelines, as shown in Appendix I. In addition to the inhalation exposure, which was the method to estimate cancer risk in the previous MATES studies, the cancer risk calculations in MATES V expanded to include risk factors accounting for multiple exposure pathways. The multiple pathway exposure includes additional air toxics cancer risk from oral exposures of toxic metals and additional exposure pathways, as discussed later in Section 4.5.

The grid cell having the maximum simulated inhalation cancer risk of 1,082 in a million was located near the Los Angeles International Airport. Several grid cells in the Ports of Los Angeles and Long Beach area have high estimated risk values, with highest at 989 in a million. In addition to the grid cells in the ports area, another group of high-risk grid cells is centered around a railyard in the southeast of downtown Los Angeles. In general, as in the past studies, the higher risk areas tend to be along transportation and goods movement corridors, consistent with areas known to have high diesel PM emissions.

Figure 4-7 provides the CAMx RTRAC simulated inhalation air toxics risk for the MATES IV period, and Figure 4-8 depicts the changes in risk from MATES IV (2012-2013) to MATES V (2018-2019). The greatest percentage decrease in risk occurred in the ports area, reflecting the emission reductions from OGVs, Commercial Harbor Craft (CHC) and other port operations including cargo handling equipment, port trucks and locomotives. The air toxics cancer risk in the ports areas decreased by approximately 57% between MATES IV and MATES V (Table 4-4). Overall, air toxics risk improved significantly, consistent with air toxic emissions reductions that occurred over the time period.

The MATES V period Basin-average population-weighted risk summed for all the toxic components yielded an air toxic cancer risk of 423 in a million for the inhalation pathway only. The average risk included all populated land cells within the South Coast Air Basin portion of the modeling domain. In comparison, the MATES IV Basin average risk was 897 per million. Between the MATES IV and MATES V periods, the modeled risk decreased by 53%. The risk reduction can be attributed to several factors, most notably, changes in diesel emissions between 2012 and 2018. As shown in Chapter 3, the overall toxic emissions reduced between the two MATES periods by 48%. The corresponding reductions from on-road and off-road mobile sources are 59% and 39%, respectively. To distinguish the impact of emission reductions from year-to-year meteorological variations, a numerical experiment using MATES V meteorology and MATES IV emissions was conducted. The result showed 49% risk reduction, indicating majority of risk reduction was due to emission reductions, while a minor portion of the improved risk was contributed by meteorology leading to better air quality.

[7] CalEPA, 2015, Office of Environmental Health Hazard Assessment, Air Toxics Hot Spots Program Risk Assessment Guidelines. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, http://www.oehha.ca.gov/air/hot_spots/hotspots2015.html

Non-diesel sources pose risk as well (Figure 4-9). The non-diesel related risk is uniformly distributed throughout the Basin with most of grids showing values approximately 100-200 in a million.

Figure 4-10 provides a close-up plot of the cancer risk in the ports area. Table 4-4 provides a summary of the cancer risk estimated for the Basin, the ports area, and the rest of the Basin excluding the ports area. For this assessment, the ports area is defined as the populated cells roughly bounded by the Interstate 405 to the north, San Pedro to the west, Balboa Harbor to the east, and Pt. Fermin to the south, as shown in Figure 4-10. The MATES V average population-weighted air toxics risk is 503 in a million in the ports area. The Basin average population-weighted air toxics risk, excluding the grid cells in the ports area, is 417 in a million. The downwind impacts resulting from port area activities are still reflected in the toxics risk estimates for the grid cells categorized as “Basin minus Ports”. Similarly, the MATES IV simulations indicated that the ports area air toxics risk was 1,177 in a million; and the Basin minus the ports area was 879 in a million. Overall, between the MATES IV and MATES V time periods, the ports area experienced an approximate 57% decrease in risk, while the average population-weighted risk in other areas of the Basin decreased by about 53%.

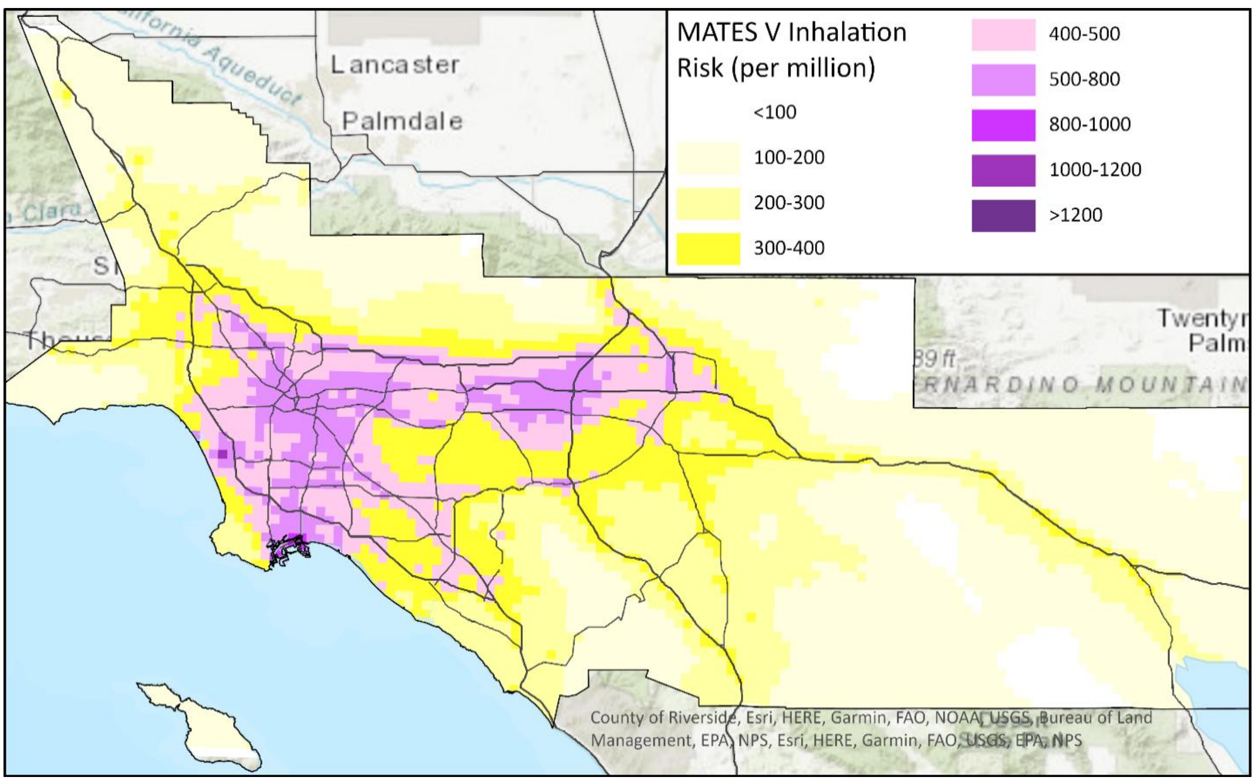

Figure 4-6
MATES V CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

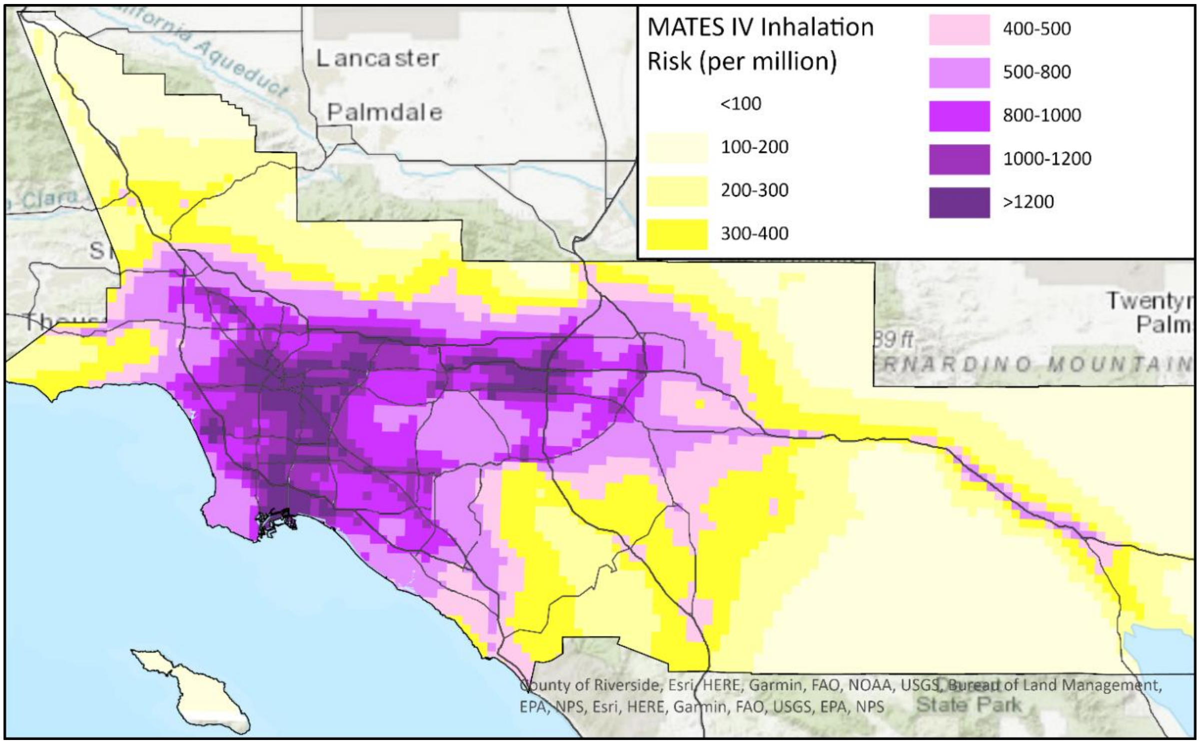

Figure 4-7
MATES IV CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk

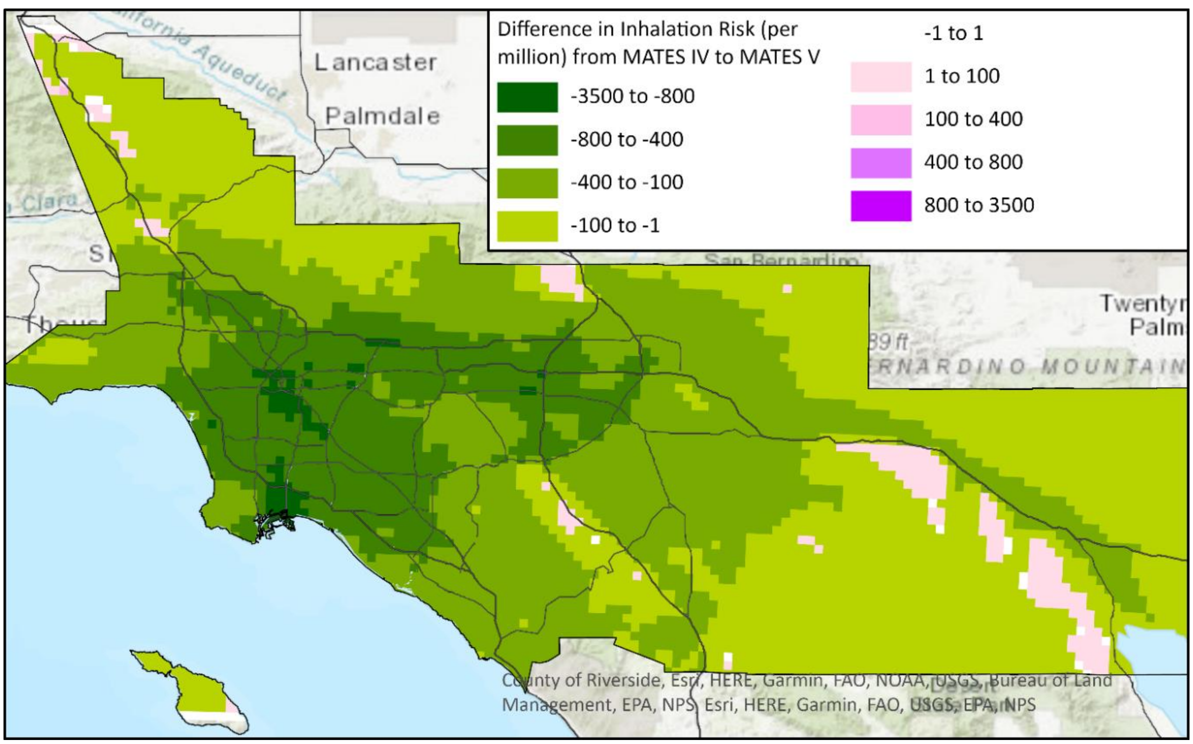

Figure 4-8
Changes in CAMx RTRAC Simulated Inhalation Air Toxics Cancer Risk (per million) from MATES IV to MATES V Period

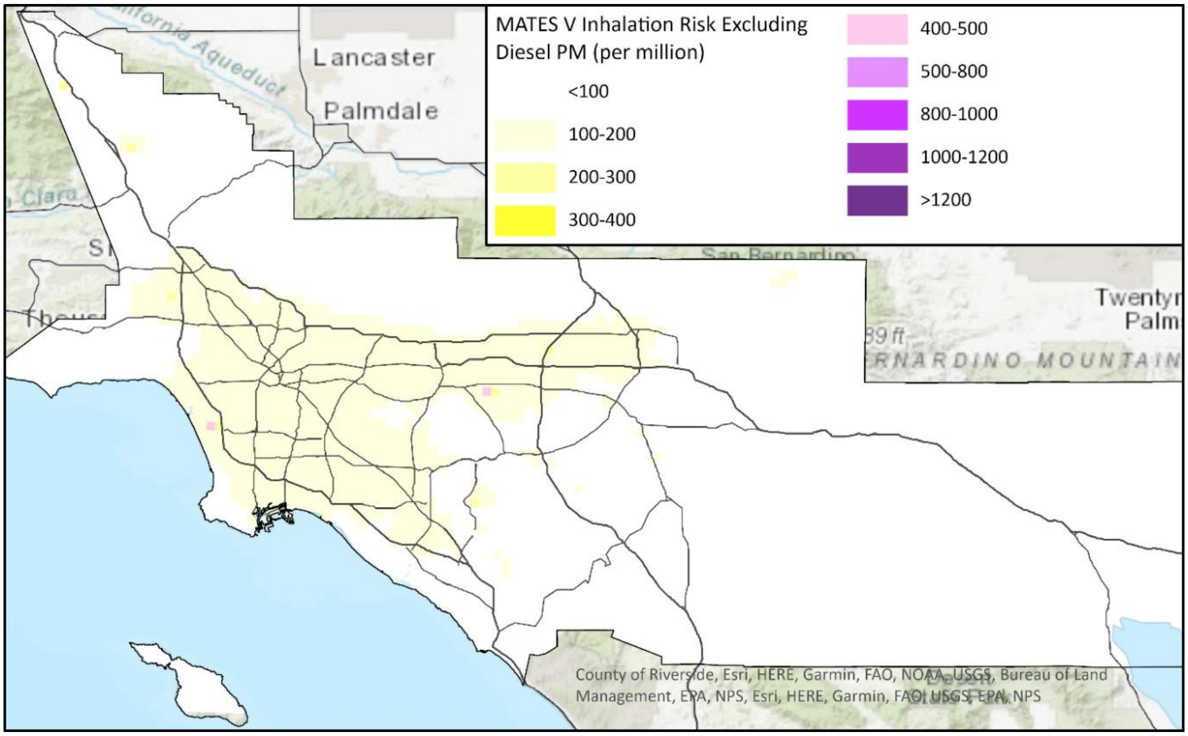

Figure 4-9
MATES V Simulated Inhalation Air Toxics Cancer Risk excluding Diesel PM

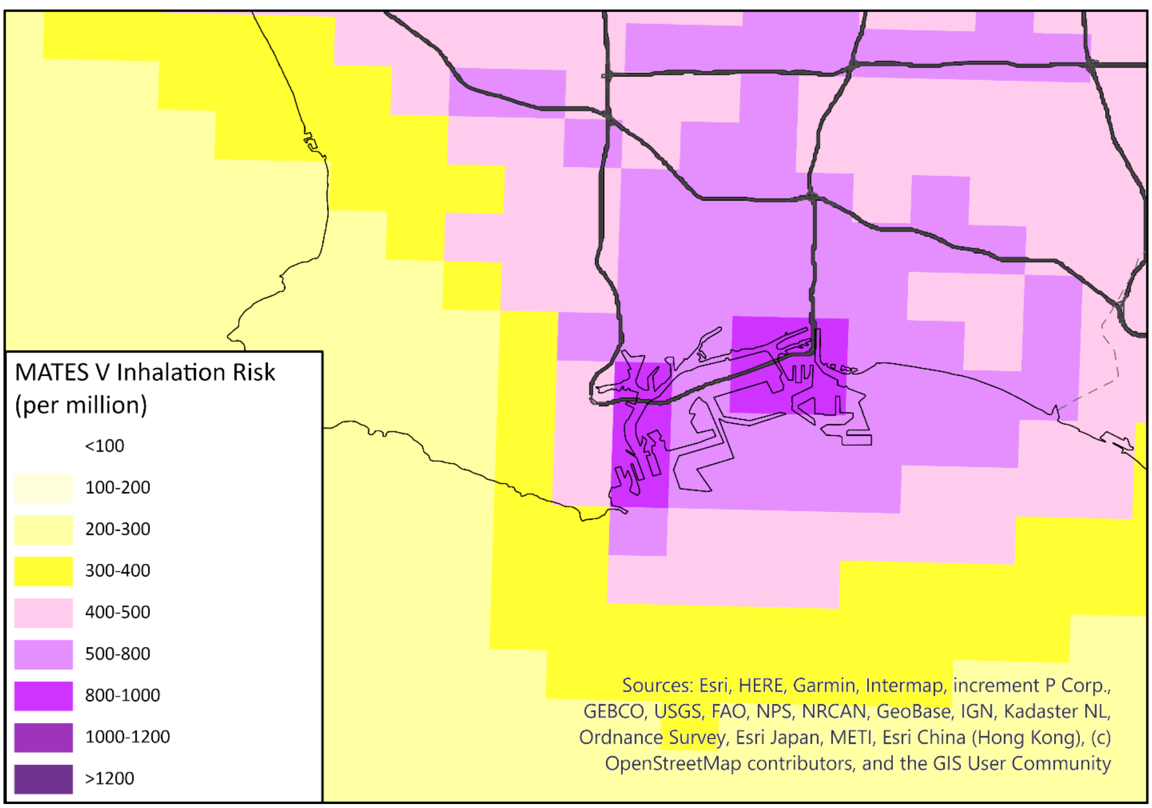

Figure 4-10
Ports Area MATES V Simulated Inhalation Air Toxics Cancer Risk

Table 4-4
Basin and Port Area Population-Weighted Cancer Risk (Inhalation Only)

Region	**MATES IV**		**MATES V**		**Average Percentage Change in Risk**
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Basin	15,991,150	897	16,599,786	423	-53
Ports Area	998,745	1,177	1,004,938	503	-57
Basin Excluding Ports Area	14,992,806	879	15,994,848	417	-53

Table 4-5 provides the county-by-county air toxics risk to the affected population. Evident from the spatial distribution map (Figure 4-6), the Basin portion of Los Angeles County bears the greatest average cancer risk of 461 per one million. The Basin portion of San Bernardino County has the second highest projected risk at 438 per one million. The estimated risk for Orange County is 363 per million, and the Basin portion of Riverside County was estimated to have the lowest population-weighted risk at 313 per million. As expected, the Coachella Valley portion of Riverside County, which does not have high density industrial activity or population, has the lowest toxic risk at 238 per million. It should be noted that these are county-wide averages, and individual communities could have higher risks than the average if they are near emissions sources, such as railyards or intermodal facilities.

Comparing county-wide population-weighted risk, Los Angeles County shows the greatest reduction among the four counties. Still, the rate of population-weighted reductions is similar in all the four counties. Reductions in emissions from mobile sources including benzene, 1,3-butadiene, and diesel PM, as presented in Chapter 3, are the primary contributors to the improved county-wide risk.

Table 4-5
County-Wide Population-Weighted Cancer Risk (Inhalation Only)

Region	MATES IV		MATES V		Average Percentage Change in Risk
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Los Angeles*	9,578,586	1015	9,846,922	461	-55
Orange	3,067,909	770	3,223,763	363	-53
Riverside*	1,784,872	543	1,912,855	313	-41
San Bernardino*	1,560,183	827	1,616,247	438	-47
South Coast Air Basin	15,991,550	897	16,599,786	423	-53
Coachella Valley	465,064	339	479,055	238	-30

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

Table 4-6 provides the Basin-wide average risk associated with each of the key air toxics modeled in the analysis. Average risks for the Coachella Valley area were not included in this table; those estimated risks are lower than the air toxics risks for the Basin. Diesel PM has the largest contribution to cancer risk from air toxics. The next three highest contributors are benzene, 1,3-butadiene and secondary formaldehyde.

Table 4-6
MATES V Inhalation Cancer Risk from Simulated Individual Toxic Air Contaminants

Toxic Compound	Risk Factor $(\mu g/m^3)^{-1}$	Max Annual Average Concentration	Population Weighted Annual Average Concentration	Units	Risk (per million)	% Contri-bution
Diesel PM	7.40E-04	1.13	0.41	$\mu g/m^3$	305.90	72.4
Benzene	6.80E-05	0.46	0.14	ppb	46.61	11.0
Secondary Formaldehyde	1.40E-05	1.41	1.06	ppb	18.33	4.3
1,3- Butadiene	4.10E-04	0.44	0.03	ppb	12.88	3.0
Primary Formaldehyde	1.40E-05	3.85	0.43	ppb	7.34	1.7
Hexavalent Chromium	3.50E-01	0.00025	2.01E-05	µg/m3	7.11	1.7
Secondary Acetaldehyde	6.80E-06	0.57	0.42	ppb	5.16	1.2
Arsenic	8.10E-03	0.018	5.89E-04	$\mu g/m^3$	3.00	0.7
Cadmium	1.00E-02	0.01	4.69E-04	$\mu g/m^3$	4.07	1.0
p-Dichlorobenzene	2.70E-05	0.07	2.37E-02	ppb	3.85	0.9
Perchloroethylene	1.40E-05	0.10	2.06E-02	ppb	1.97	0.5
Nickel	6.20E-04	0.16	2.82E-03	$\mu g/m^3$	1.77	0.4
Primary Acetaldehyde	6.80E-06	0.94	0.13	ppb	1.61	0.4
Naphthalene	8.10E-05	0.036	3.46E-03	ppb	1.47	0.3
Methylene Chloride	2.40E-06	0.64	0.15	ppb	1.29	0.3
Trichloroethylene	4.70E-06	0.08	8.34E-03	ppb	0.21	<0.1
Lead	2.80E-05	0.035	3.21E-03	$\mu g/m^3$	0.08	<0.1

Table 4-7 provides the simulated air toxics risk at each of the 10 stations for the top three toxic compounds and the remaining aggregate contributing to the overall risk. Risk is calculated using each toxic component concentrations predicted for the specific monitoring station location. The model prediction comparison used the nine-cell average at the grid corresponding to a monitoring station and its surrounding 8 grid cells using an inverse distance squared weighting factor. The summary also provides the comparison between simulated average risk for the 10 stations and the average risk calculated using the annual toxic compound measurements. Since diesel PM cannot be measured, measurement-based risk is calculated using an $EC_{2.5}$ to diesel PM conversion as described in Chapter 2 to estimate the diesel PM contributions. The comparison to measured risk was conducted with the 7 stations which are listed in the previous section.[8]

[8] Burbank Area, Compton, Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach

Table 4-7

Modeled Inhalation Cancer Risk at monitoring locations and Monitoring-Based Risk

Location	MATES V CAMX RTRAC Simulation				
	Benzene	1,3-Butadiene	Diesel	Others	Total
Anaheim	48	13	307	56	425
Burbank Area	58	16	381	72	526
Central Los Angeles	65	21	499	82	667
Compton	53	15	381	70	519
Inland Valley San Bernardino	46	12	361	86	505
Huntington Park	57	20	407	75	559
Long Beach	52	16	359	65	492
Pico Rivera	50	11	368	63	492
Rubidoux	39	9	294	48	389
West Long Beach	60	20	455	80	615
10-Station Average Modeled	53	15	382	70	519
7-Station Average Modeled	54	16	387	73	530
7-Station MATES V Average Measured*	62	56	362	114	593

*Includes modeled species only. Risk from some measured species, such as carbon tetrachloride, chloroform and PAHs are excluded. Measured $EC_{2.5}$ was converted into diesel PM as described in Chapter 2

Among the monitored locations, the highest risk was simulated in Central Los Angeles followed by West Long Beach and Huntington Park. The lowest modeled risk was simulated at Rubidoux. With continued diesel PM reductions in port operations, the West Long Beach is no longer the highest risk site as it was in the previous MATES. Additionally, the modeled risk at the Long Beach station is below the overall average risk across all stations, although the location of the Long Beach station was relocated from an area near the I-710 to a mostly residential location southeast of the previous location. The MATES V monitoring with the highest air toxics cancer risk was Inland Valley San Bernardino. This inland location is located in an area near major goods movement land uses.

Based on modeled concentrations, the cancer risk averaged over the 7 stations is 530 in a million, which is approximately 11% lower than the measurement-based risk as shown in Figure 4-11.

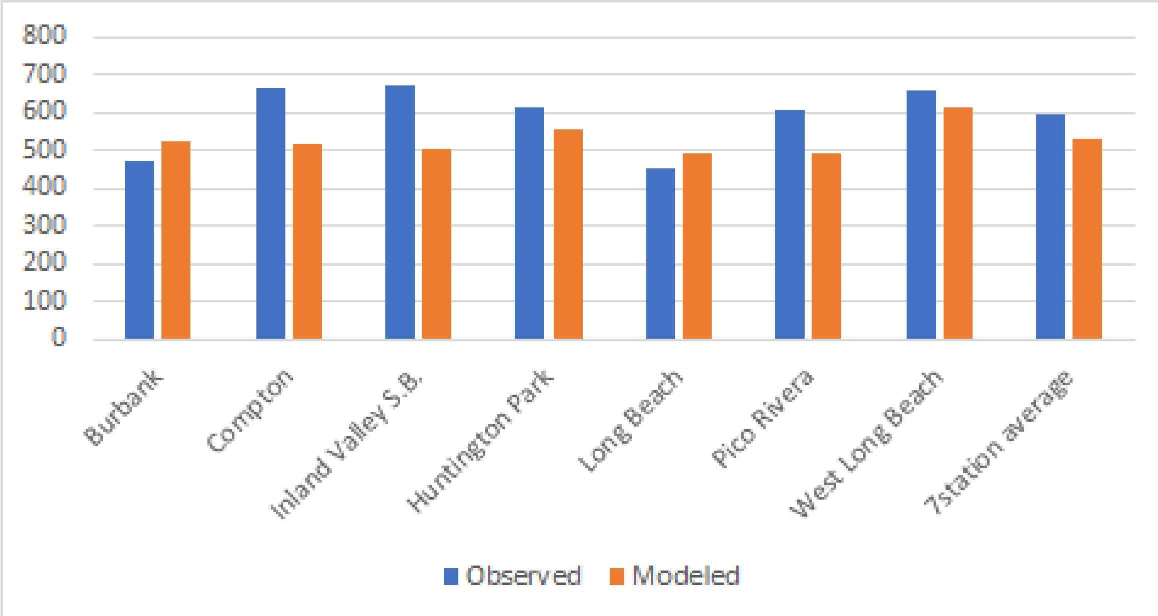

Figure 4-11

MATES V Modeled vs. Measured Inhalation Air Toxics Cancer Risk (Per Million)

The portion of the simulated cancer risk attributed to air toxics other than diesel PM can be directly compared to risk calculated from the toxic compound measurements. Figure 4-12 presents a comparison of the model simulated and measurement-based non-diesel risk at each monitoring site, as well as the 7-station average. The modeled non-diesel risk at each station is 27 to 50% lower than the risk calculated based on measurement data, with the modeled 7-station average cancer risk being 39% lower than the measurement-based risk. This difference in non-diesel risk is primarily due to underprediction of concentrations of formaldehyde, acetaldehyde and 1,3-butadiene and, to a lesser extent, benzene.

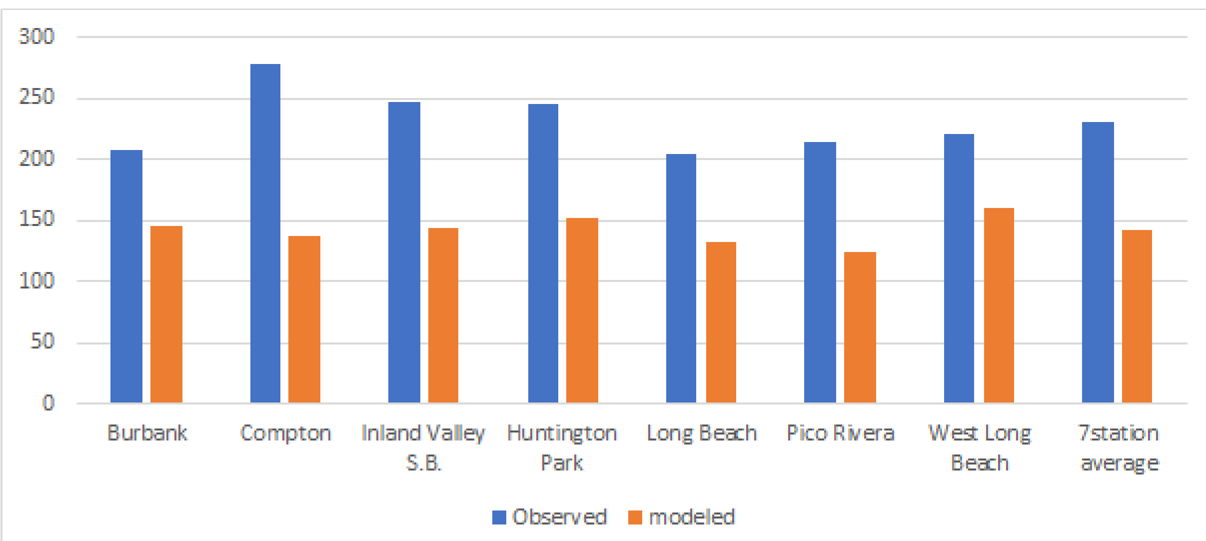

Figure 4-12

MATES V Simulated vs. Measured Non-Diesel Inhalation Air Toxics Cancer Risk (Per Million)

4.5 Multiple-Pathway Cancer Risk

The cancer risk discussed in the previous section was based on inhalation exposure only, which was the practice used in previous MATES studies. Among the toxic species included in the modeling, arsenic, hexavalent chromium and lead have associated cancer risks from non-inhalation exposures. This additional cancer risk can be assessed by a multiple-pathway factor. For arsenic, hexavalent chromium and lead, the multiple-pathway factors are 9.71, 1.6 and 11.41, respectively. These factors account for oral and dermal exposures for these toxic metals. The overall multiple-pathway risk due to the inclusion of the three metals was estimated to be 454 per million, which is approximately 7.3% higher than the inhalation-only risk. Table 4-8 lists average risks for individual county and Coachella Valley. Figure 4-13 depicts the MATES V distribution of multiple-pathway cancer risk estimated from the predicted annual average concentrations of the modeled toxic compounds. Compared to Figure 4-6, where only inhalation toxic risk is depicted, additional risk from oral exposure of arsenic, hexavalent chromium and lead elevated the overall risk in some areas. County-wide and air basin level population weighted cancer risks are compared to MATES IV modeling results in Table 4-9. The reduction in the multiple-pathway risk is similar to the inhalation-only risk trends as shown in Table 4-5.

Table 4-8
County-Wide Population-Weighted Air Toxics Cancer Risk for Inhalation-Only and for Multiple-Pathway Factors

Region	2018 Population	Inhalation-Only	Multiple-Pathway
		Average Risk (Per Million)	Average Risk (Per Million)
Los Angeles*	9,846,922	461	497
Orange	3,223,763	363	388
Riverside*	1,912,855	313	332
San Bernardino*	1,616,247	438	470
Basin	16,599,786	423	454
Coachella Valley	479,055	238	249

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

Table 4-9
County-Wide Population-Weighted Multiple-Pathway Cancer Risk

Region	MATES IV		MATES V		Average Percentage Change in Risk
	2012 Population	Average Risk (Per Million)	2018 Population	Average Risk (Per Million)	
Los Angeles*	9,578,586	1143	9,846,922	497	-57%
Orange	3,067,909	829	3,223,763	388	-53%
Riverside*	1,784,872	586	1,912,855	332	-43%
San Bernardino*	1,560,183	905	1,616,247	470	-48%
South Coast Air Basin	15,991,550	997	16,599,786	454	-54%
Coachella Valley	465,064	357	479,055	249	-30%

* Data for these counties reflects the South Coast Air Basin portion only. Please note that all of Orange County is within the South Coast Air Basin.

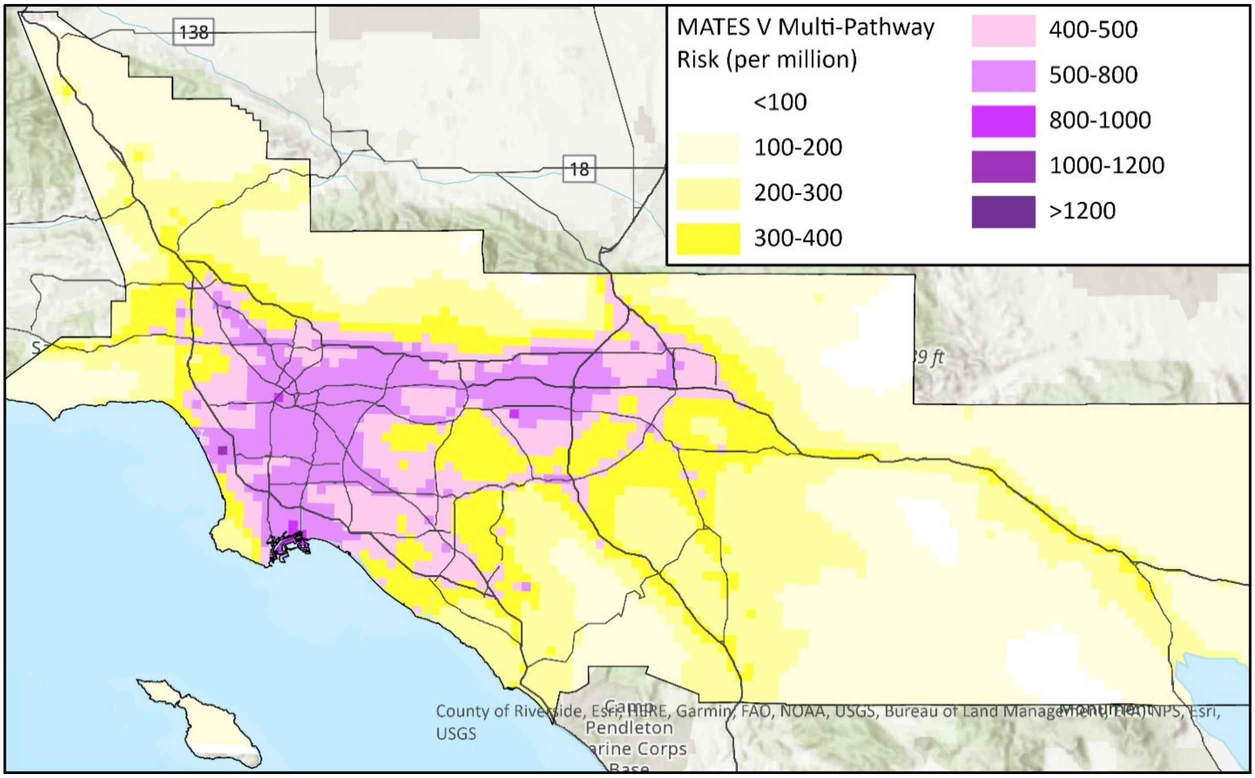

Figure 4-13
MATES V CAMx RTRAC Simulated Multiple-Pathway Air Toxics Cancer Risk

4.6 Chronic Non-Cancer Risk from Exposure to Air Toxics

Previous MATES studies focused only on air toxics cancer risk. However, some chemical components captured in measurements have exclusively cancer, exclusively non-cancer, or both impacts on human health. To evaluate chronic non-cancer health risks related to air toxics, Chapter 2 presents an exploratory analysis of chronic non-cancer risks based on measurement data. Given the exploratory nature of the chronic non-cancer risk analysis, and the complexities involved in estimating the spatial distribution of the measured compounds that appear to contribute most to this risk based on the monitoring data, this analysis cannot be repeated with the modeled air toxics data without substantial uncertainty. Some species that appear to be risk drivers based on the monitoring data were not estimated in the modeling. However, future iterations of MATES may consider this detailed analysis of chronic non-cancer risks, using the exploratory analysis to help inform which species may need to be included in the modeling efforts.

4.7 Analysis of Air Toxics Risks in Environmental Justice Communities

Environmental justice (EJ) communities are disproportionately impacted by various types of pollution and experience health, social, and economic inequities that also can make residents more sensitive or more vulnerable to the effects of environmental pollution. To evaluate the impacts and trends of toxic air contaminants in EJ communities, the MATES V study includes an analysis of the air toxics health risks in EJ communities as compared to the average risks throughout the jurisdiction.

While there is no universal definition for what constitutes an EJ community, one commonly used definition is the Senate Bill (SB) 535 definition of disadvantaged communities in California. SB 535 disadvantaged communities are defined as the "25% highest scoring census tracts in CalEnviroScreen 3.0", along with "22 census tracts that score in the highest 5% of CalEnviroScreen's Pollution Burden, but do not have an overall CalEnviroScreen score because of unreliable socioeconomic or health data".[9] For this analysis, only the SB535 disadvantaged communities located inside the SCAB were evaluated. The SB535 communities are shown in Figure 4-15.

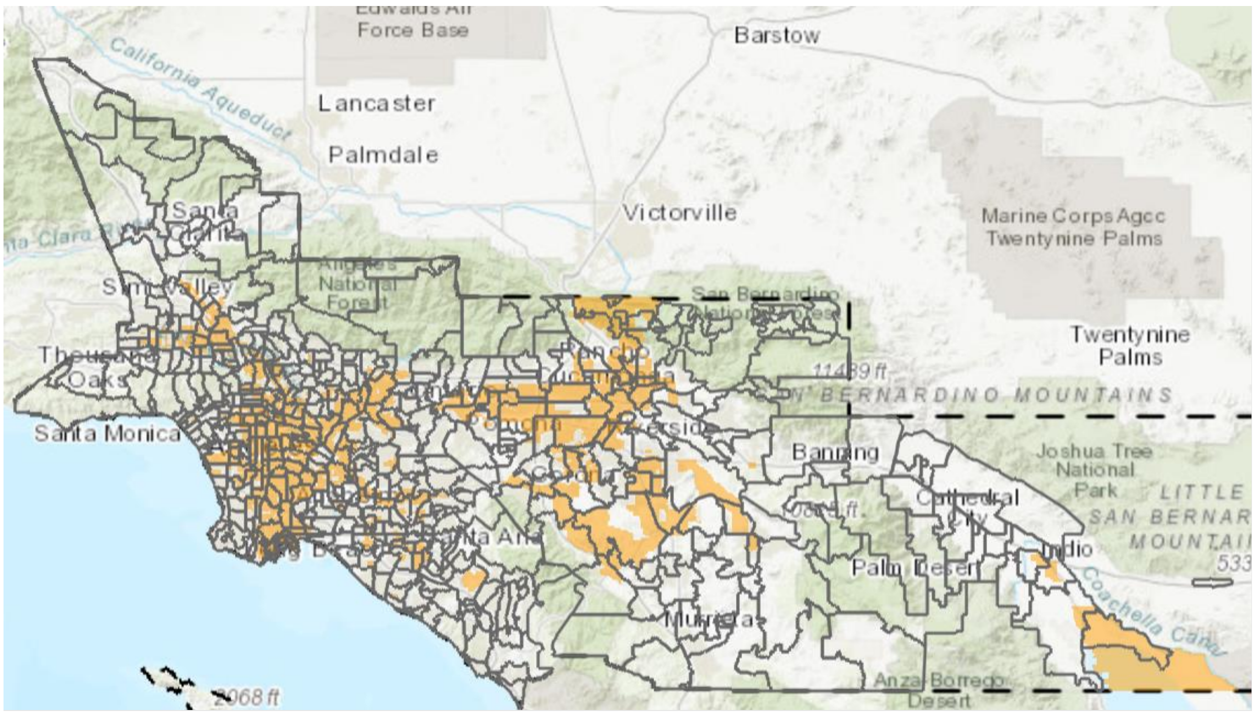

Figure 4-15: SB535 Communities

To conduct this analysis, staff first determined which of the model grid cells intersected each community boundary, and then calculated the population-weighted average residential air toxics cancer risk and population-weighted average chronic risk for those grid cells. This calculation was done using MATES IV and MATES V model data. Next, the difference in modeled risks from MATES IV to MATES V was calculated. While there are no set "thresholds" that these overall health risk results should aim to meet, it may be helpful to illustrate the magnitude of the health risk by using the AB 2588 program's significant risk thresholds for cancer risk. The AB 2588 Air Toxics Hot Spots program and South Coast AQMD's Rule 1402 establishes the significant risk level as ≥100-in-a-million for cancer risk.[10] However, this threshold applies only

[9] https://oehha.ca.gov/calenviroscreen/sb535
[10] https://www.aqmd.gov/home/rules-compliance/compliance/toxic-hot-spots-ab-2588/risk-reduction

to the risk based on emissions from a single facility, whereas MATES evaluates the combined emissions from all sources. In other words, it is not surprising that the MATES health risk levels are higher than the AB 2588 and Rule 1402 significant risk level.

Figure 4-16 shows the air toxics health risk trends in EJ communities in the SCAB (defined by SB 535) and non-EJ communities. Between MATES IV and MATES V, air toxics cancer risk decreased by 57% in EJ communities overall compared to a 53% reduction in non-EJ communities. Importantly, although air toxics cancer risks have decreased overall, and especially decreased substantially in EJ communities, people living in EJ communities in the SCAB continue to experience higher air toxics cancer risks compared to those in non-EJ communities.

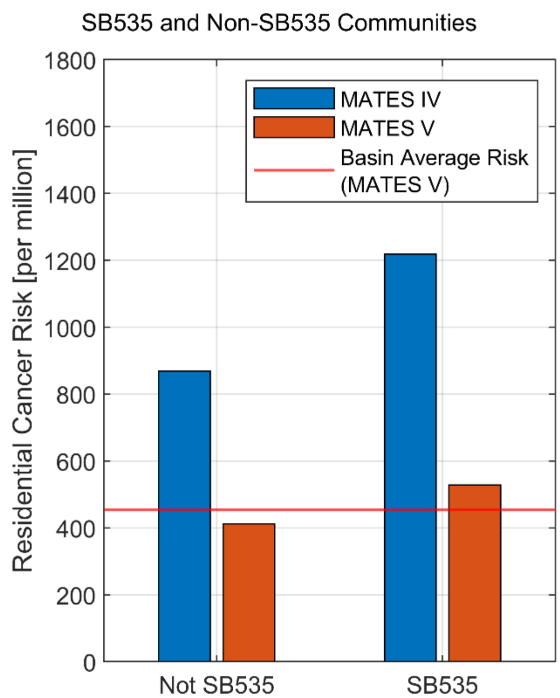

Figure 4-16: Population weighted average Residential Cancer Risk in SB535 and Non-SB535 Communities.

In 2017, Assembly Bill (AB) 617 was signed into law to address air quality disparities in EJ communities across the state. Among the many AB 617 program elements that aim to bring air quality benefits to EJ communities, one part of the program involves the designation of specific communities for the development of community plans. As of March 2021, there are six communities in the South Coast AQMD that have been designated for the AB 617 program[11]. The community boundaries for the 5 communities that were designated in 2018 and 2019 are shown in Figure 4-17; the sixth community (South Los Angeles) was designated in February 2021, and as of this writing, this community does not yet have a finalized AB 617 community boundary.

[11] www.aqmd.gov/ab617

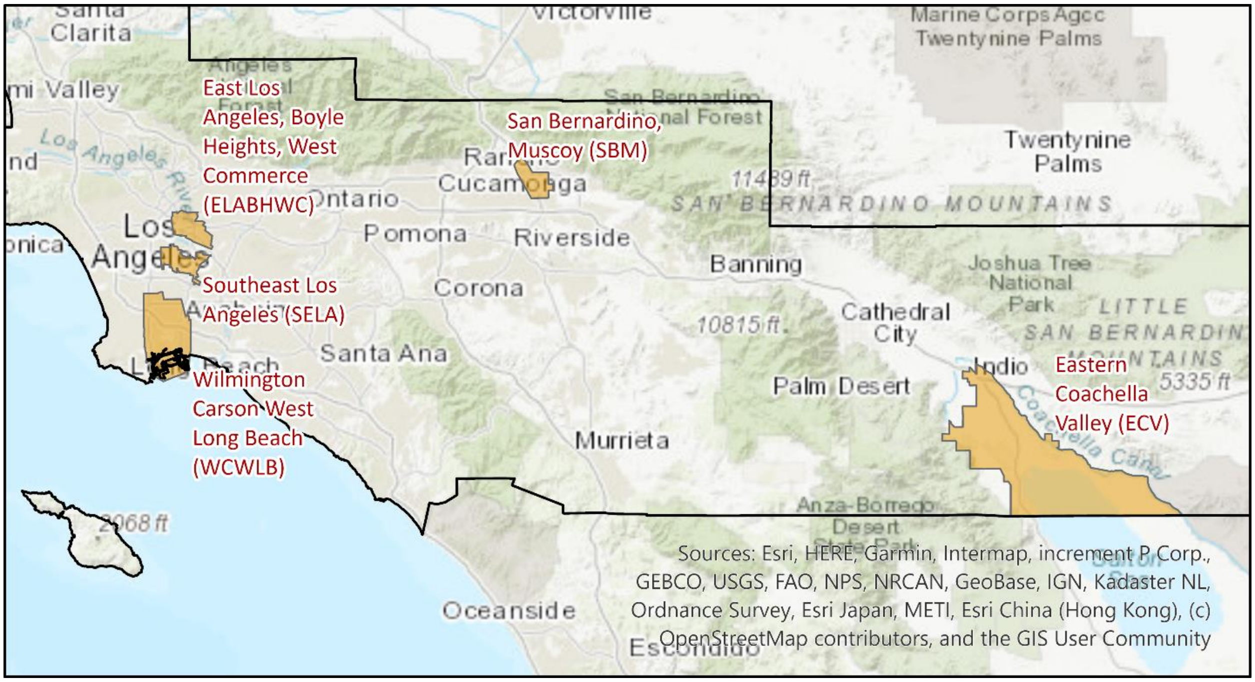

Figure 4-17: AB 617 Designated Communities in the South Coast AQMD

The air toxics cancer risks are shown for each of these five communities designated for the AB 617 program:

1. Wilmington, Carson, West Long Beach (WCWLB)
2. San Bernardino, Muscoy (SBM)
3. East Los Angeles, Boyle Heights, West Commerce (ELABHWC)
4. Southeast Los Angeles (SELA)
5. Eastern Coachella Valley (ECV)

Through the AB 617 program, staff worked with each of these communities to develop a Community Emissions Reduction Program (CERP). The plans are designed to be implemented over the course of approximately five years, and these plans are in the relatively early stages of implementation. The MATES V modeling results reflect the conditions in the year 2018, which is prior to any of these CERPs being approved. Therefore, the MATES V data could be used as an estimate of the air toxics levels in these communities before the CERPs and other programs (including regulatory programs) have taken effect.

The community of Wilmington, Carson, West Long Beach (WCWLB) is located in the southern portion of Los Angeles County, and is home to more than 300,000 people. This community was designated for the AB 617 Community Air Program in 2018. More than half of the people living in this community are Hispanic or Latinx. About 17.6% of the residents in this community are Asian American and 16.6% are African American. The community's rates of asthma-related emergency department visits are more than 40% higher than the state average, and the community also experiences higher rates of linguistic isolation, poverty, unemployment, and other social and economic disadvantages, compared to state averages. The community includes about 72 square miles of land area. About 25% of this land area is used for residential living, 25% is zoned for industrial uses, and 23% is used for freeways, roadways, and land used for utilities and communications services. Within this community, there are 78 facilities in the U.S. EPA Title V program, 54 facilities in the AB 2588 Air Toxics Hot Spots program, 43 miles of freeways, 9 rail yards, and 2 major marine ports. Between MATES IV and MATES V, the air toxics cancer risk decreased by 57% in the WCWLB community (Figure 4-18). Based on MATES V data, air toxics cancer risk in this community (612-in-a-million) remains higher than the overall average in the SCAB.

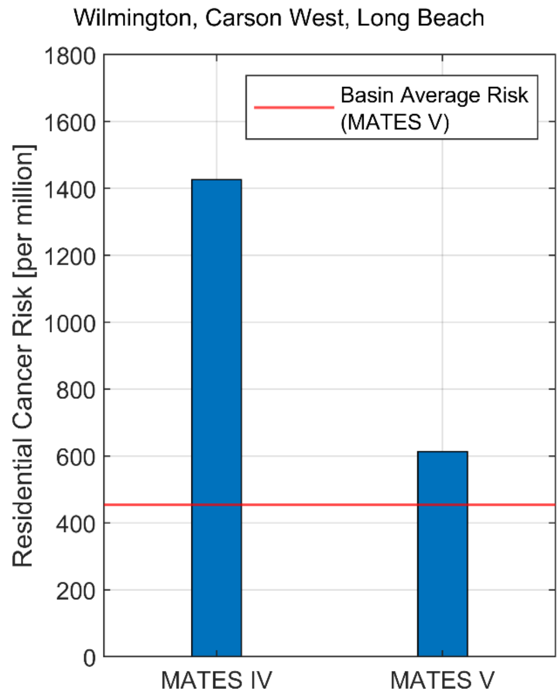

Figure 4-18: Population weighted average Residential Cancer Risk in Wilmington, Carson, West Long Beach.

The community of San Bernardino, Muscoy (SBM) is located in central San Bernardino County, and is home to more than 90,000 people. This community was designated for the AB 617 Community Air Program in 2018. About 74% of the residents in this community are Hispanic or Latinx, 13.1% are African American, and 9.3% are White. The community's rates of asthma-related emergency department visits are more than double the state average, and the community also experiences substantially higher rates of poverty, unemployment, and other social and economic disadvantages, compared to state averages. Of the 17.3 square miles of land area in this community, 48% of this land is used for residential living, 19% is zoned for commercial use, and 7% is zoned for industrial uses, and 7% is used for freeways, roadways, and land used for utilities and communications services. Within this community, there are 22 miles of freeways and 5 railyards. Between MATES IV and MATES V, the air toxics cancer risk decreased by 43% in the SBM community (Figure 4-19). Based on MATES V data, air toxics cancer risk in this community (506-in-a-million) remains higher than the overall average in the SCAB.

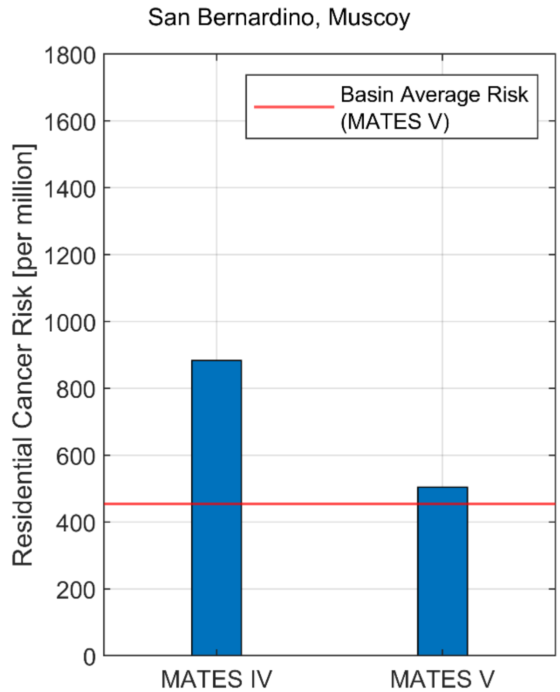

Figure 4-19: Population weighted average Residential Cancer Risk in San Bernardino, Muscoy.

The community of East Los Angeles, Boyle Heights, West Commerce (ELABHWC) is located in central Los Angeles County, and is home to more than 220,000 people. This community was designated for the AB 617 Community Air Program in 2018. More than 95% of the residents in this community are Hispanic or Latinx. This community has higher rates of asthma-related and cardiovascular disease-related emergency department visits are about 20% higher than the state averages, and the community experiences substantially higher rates of poverty, linguistic isolation, and other social and economic disadvantages, compared to state averages. Of the approximately 19 square miles of land area in this community, 41% of this land is used for residential living, 19% is zoned for commercial use, and 21% is zoned for industrial uses, and 10% is used for freeways, roadways, and land used for utilities and communications services. Within this community, there are more than 30 miles of freeways and 5 railyards. Between MATES IV and MATES V, the air toxics cancer risk decreased by 61% in the ELABHWC community (Figure 4-20). Of the 5 designated AB 617 communities analyzed here, the ELABHWC community had the highest cancer risk during MATES IV, but also experienced the largest reduction in cancer risk (-1037 chances in a million), largely due to reductions in diesel particulate matter. Based on MATES V data, air toxics cancer risk in this community (652-in-a-million) remains higher than the overall average in the SCAB.

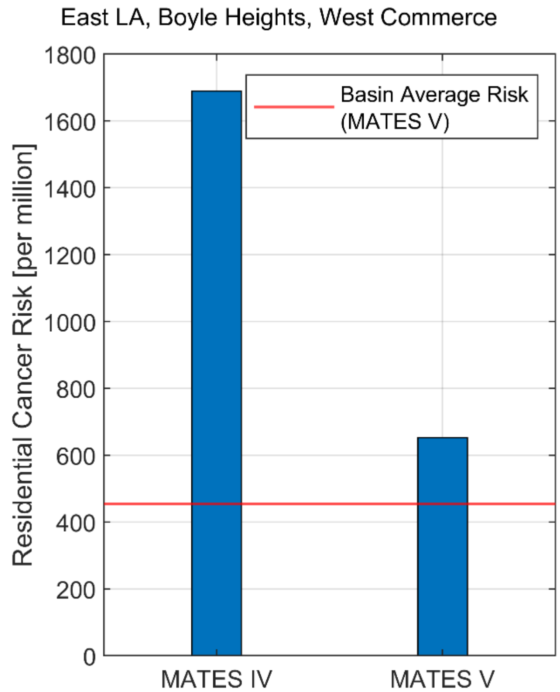

Figure 4-20: Population weighted average Residential Cancer Risk in East LA, Boyle Heights, West Commerce.

The community of Southeast Los Angeles (SELA) is located in central Los Angeles County, and is home to more than 290,000 people. This community was designated for the AB 617 Community Air Program in 2019. About 95% of the residents in this community are Hispanic or Latinx. Of the approximately 18 square miles of land area in this community, 56% of this land area is used for residential living, 18% is zoned for commercial uses, 15% is zoned for industrial uses, and 5% is used for freeways, roadways, and utilities and communications services. Air pollution sources in this community include the I-710 freeway, locomotives and industrial facilities along the Alameda Corridor, and facilities in the adjacent industrial city of Vernon. Between MATES IV and MATES V, the air toxics cancer risk decreased by 63% in the SELA community (Figure 4-21). Based on MATES V data, air toxics cancer risk in this community (567-in-a-million) remains higher than the overall average in the SCAB.

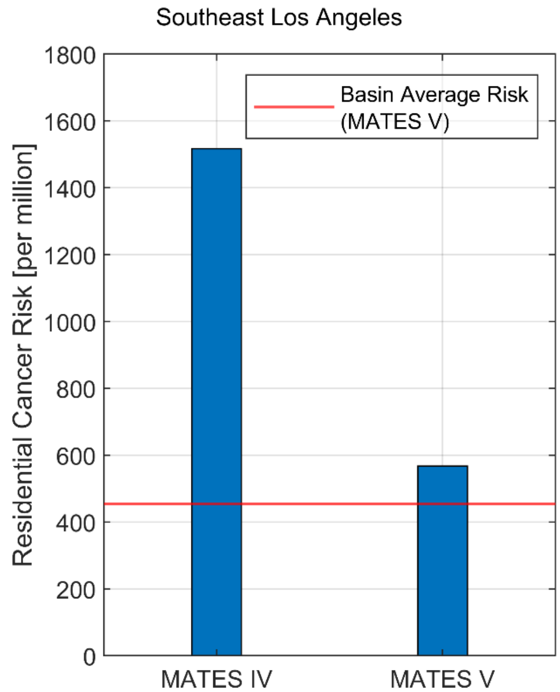

Figure 4-21: Population weighted average Residential Cancer Risk in Southeast Los Angeles.

The community of Eastern Coachella Valley (ECV) is located in Riverside County, and is home to more than 80,000 people. This community, which includes several cities and rural communities, was designated for the AB 617 Community Air Program in 2019. About 92% of the residents in this community are Hispanic or Latinx. ECV is home to four Tribal Reservations (Figure 3a-2). These include the Twenty-Nine Palms Band of Mission Indians Tribe, the Cabazon Band of Mission Indians Tribe, the Torres-Martinez Desert Cahuilla Indians Tribe, and the Augustine Band of Cahuilla Indians Tribe. Of the 288 square miles of land area in this community, about 2% of this land area is used for residential living, 1% is zoned for commercial uses, 1% is zoned for industrial uses, 3% is used for freeways, roadways, and utilities and communications services, 29% is used for agriculture which is land that is used primarily for the production of food, fiber, and livestock, 39% is used for vacant land which is land that had not been built-up with man-made structures, and 25% is water which includes open water bodies which are greater than 2.5 acres in size. There are multiple sources of pollution in the region that are associated with agricultural activities, goods movement, industrial facilities and hazardous waste facilities. The Salton Sea is also a major environmental concern in the community. Between MATES IV and MATES V, the air toxics cancer risk decreased by 31% in the ECV community (Figure 4-22). Based on MATES V data, the air toxics cancer risk in this community (282-in-a-million) is lower than SCAB averages, but higher than the overall average in the Salton Sea Air Basin (SSAB). There are some important limitations that may impact the ability to capture the air toxics cancer risk in the ECV community. First, the MATES V is not able to account for potential pesticide exposures and associated health risks. Second, the emissions inventory is not able to account for illegal burning activities which occur in this community. Therefore, while the results from the MATES V study would be helpful to compare to future data, these results should be interpreted with caution.

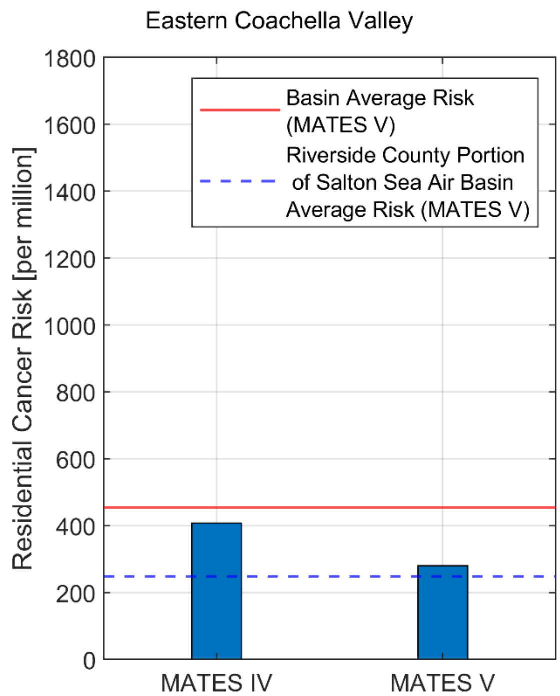

Figure 4-22: Population weighted average Residential Cancer Risk in Eastern Coachella Valley.

4.8 Summary and Conclusions

The MATES V study used CAMx with RTRAC algorithm, WRF, MEGAN and mobile source emissions modeling systems to model air toxics cancer risk for the MATES V study. The population-weighted average Basin air toxics cancer risk using multiple-pathway factors is 454 in a million, and the average inhalation-only risk is 423 in a million. The areas of the Basin that are exposed to the higher air toxics cancer risk continue to be along the goods movement corridors. The MATES V risk in the SCAB is estimated to be 55% lower than the corresponding risk during the MATES IV period (997 in-a-million for multiple pathway risk). Much of the air toxics cancer risk reduction was due to the 51% reduction of diesel particle emissions between 2012 and 2018. In particular, diesel PM from OGV/CHC in the ports area reduced by 60% between 2012 and 2018. Diesel PM continues to be the primary risk driver, contributing to more than 72% of the inhalation-only risk and 67% of the overall multiple pathway air toxics cancer risk. The air toxics cancer risk in the Coachella Valley is estimated to be 249 in-a-million, based on multiple exposure pathways. The changes of other toxic compounds emissions marginally contribute to the overall reduction in the MATES V simulated risk. Overall carcinogenic emissions during the MATES V period are lower than the MATES IV by 48%. The simulated risk showed a greater rate of reduction than the corresponding risk derived from measurements, which showed 31% reduction from MATES IV. Los Angeles County continues to have the highest among the four counties in air toxics cancer risk. Although the single highest grid cell is the one encompassing LAX, there are several grid cells in the ports area that are above 900-in-a-million for air toxics cancer risk.